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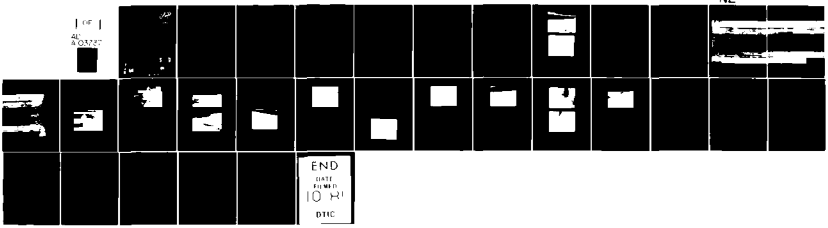

Special Report 81-10

May 1981

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FABRIC INSTALLATION TO MINIMIZE REFLECTION CRACKING ON TAXIWAYS AT THULE AIRBASE, GREENLAND

Robert A. Eaton and Randy Godfrey

Prepared for
U.S. AIR FORCE
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COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE, U.S.A.

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In August 1978 two types of fabrics were placed on sections of taxiways 1 and 3 of Thule AB, Greenland, to study the ability of fabrics with an AC 2.5 overlay to minimize reflection cracking in severe climates. Both fabrics should retain durability and mechanical strength under Thule's arctic conditions.

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PREFACE

This report was prepared by Robert A. Eaton, Research Civil Engineer and Randy N. Godfrey, Civil Engineering Technician, both of the Geotechnical Research Branch, Experimental Engineering Division, US Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

Funding for this study was provided by the U.S. Air Force Military Construction Project 4K078012AAM1-(O&MA), Facilities Investigation and Studies Program; Work Unit 106, Placement of AC Pavements at Low Temperatures.

The authors would like to thank L. Gray and J. Roberson, Phillips 66 representatives; E. Gothard, Monsanto representative; D. Murray, Resident Engineer at Thule; the Superfos personnel, the Danish DAC support personnel, the U.S. Air Force personnel, and any others involved with this project at Thule.

We would also like to thank R. Berg, N. Smith, and W. Quinn of CRREL for their reviews of this report.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

In 1976 the Corps of Engineers changed its specifications for the selection of asphalt cements for use in cold regions from a penetration specification to a penetration-viscosity number (PVN) specification (Department of the Army 1976). These new specifications required use of a select grade of AC (asphalt cement) 2.5 for a white-painted runway overlay which was constructed at Thule AB, Greenland in the summer of 1977 (Eaton and Godfrey 1980).

Sections of the Thule AB taxiway system were to be overlaid in the summer of 1978. In an effort to try to minimize reflection cracking through the overlay, CRREL asked the U.S. Air Force if it would be possible to install a fabric beneath the softer AC 2.5.

In 1977 the Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi began a nationwide field study at various Army bases on the effectiveness of fabrics for reducing reflection cracking. CRREL contacted WES and asked for recommendations of fabrics that should be used at Thule. Based upon the results of their field study, WES recommended two fabrics: the Phillips Fibers Corporation PETROMAT and the Monsanto BIDIM, 6-oz/yd^2 fabrics.

The Phillips representatives felt that 6 oz/yd^2 might be heavier than necessary and suggested trying their 4-oz/yd^2 fabric. The Monsanto representatives felt that 6 oz/yd^2 might be too light and suggested trying their 8-oz/yd^2 fabric. All three fabric weights were used.

Test section design

By 24 July 1978 the plans and designs for the fabric and overlay test sections had been completed by the New York District, Corps of Engineers and the U.S. Air Force. They decided to place the 6-oz/yd^2 fabrics on taxiway 3 for comparative evaluations (Fig. 1). The test area on taxiway 3 was 75 ft wide x 500 ft long, with a proposed overlay thickness of 2 in. (Fig. 2). The 8-oz/yd^2 BIDIM and 4-oz/yd^2 PETROMAT fabrics were placed on the east end of taxiway 1 (Fig. 1). The PETROMAT was placed in an area 51 ft wide x 500 ft long and the BIDIM was placed next to it in an area 52 ft wide x 400 ft long (Fig. 3). The proposed

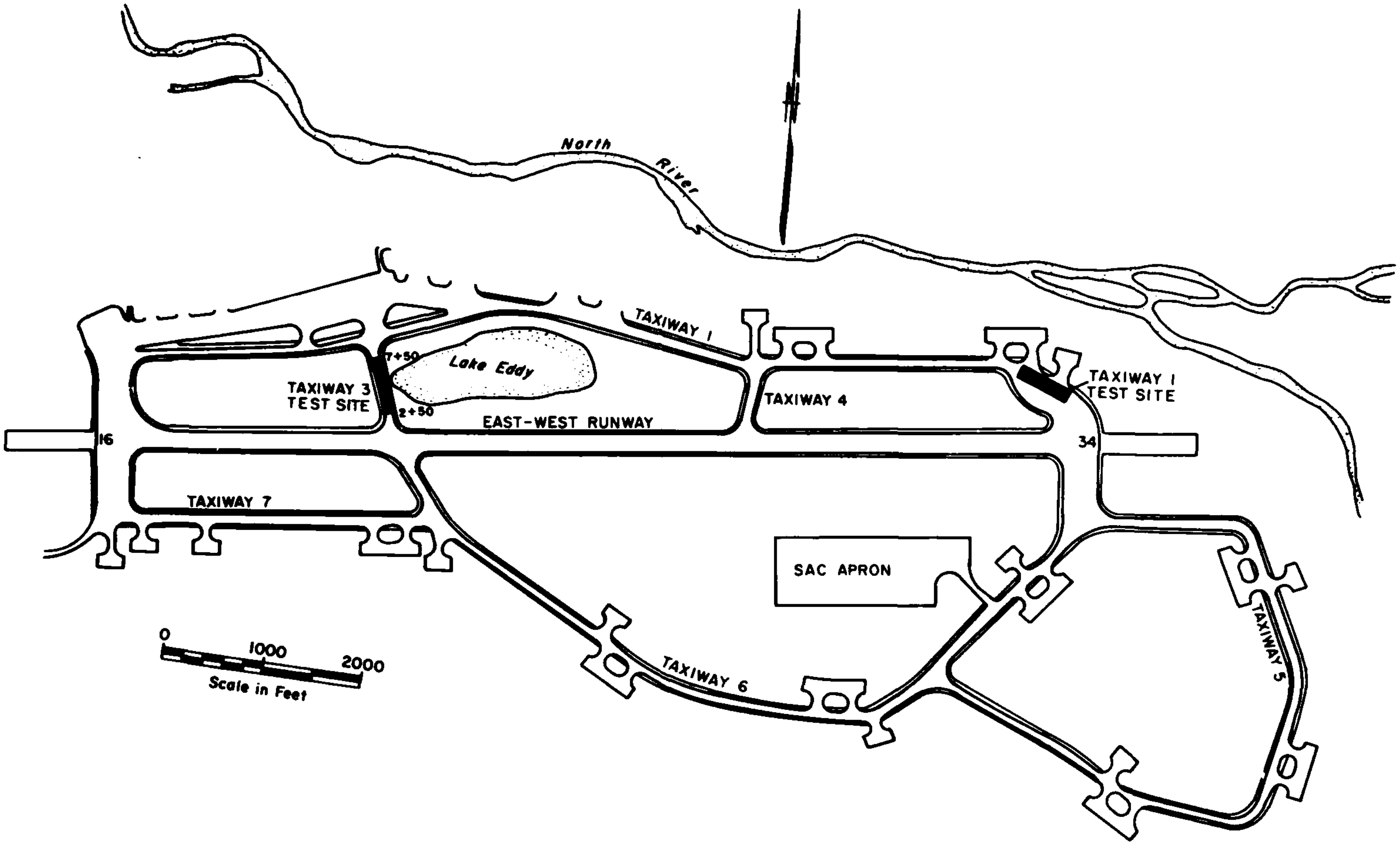


Figure 1. Thule Airbase, Greenland.

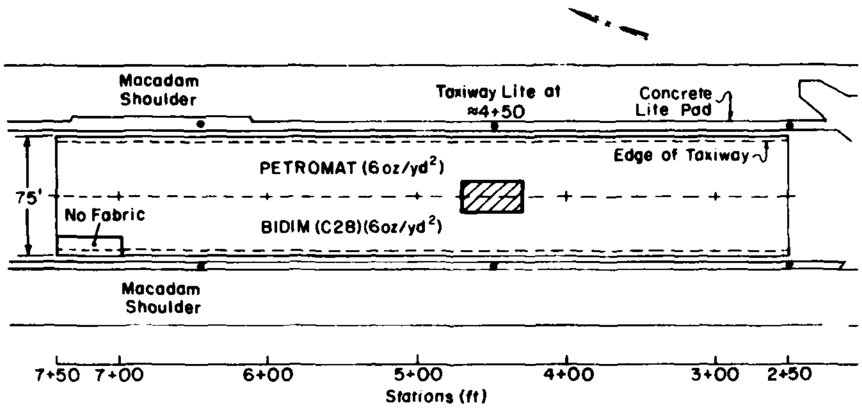


Figure 2. Plan view of taxiway 3 (shaded area shown in Fig. 6).

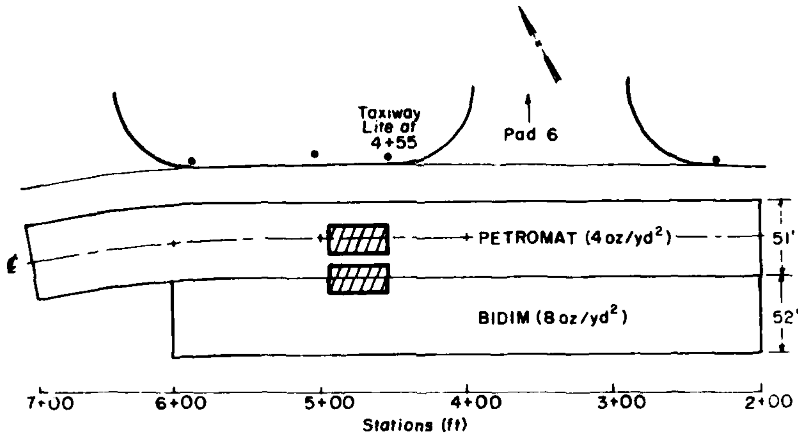


Figure 3. Plan view of taxiway 1.

overlay was also a minimum of 2 in. thick in this area.

The Monsanto 6-oz/yd^2 BIDIM C 28 fabric was packaged with 170 linear feet per roll, was 166 in. wide, and weighed 117 lb. The 6-oz/yd^2 Phillips PETROMAT weighed 176 lb per roll and measured 150 in. wide by 300 ft long. The 4- and 8-oz/yd^2 fabrics had the same dimensions as both 6-oz/yd^2 fabrics but the former weighed less and the latter gave more per roll.

Field construction

The contractor was Superfos, Denmark's largest group of industrial companies. To insure proper fabric installation, Phillips and Monsanto sent representatives to Thule to observe the placement of the fabric.

Figure 4. Milled surface.

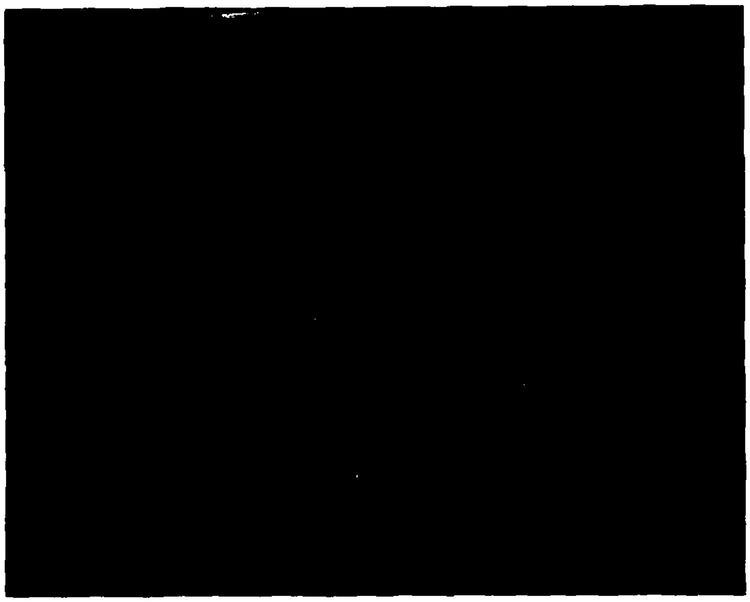


Figure 5. White paint left on surface after milling.

TAXIWAY 3 TEST SECTION

Surface preparation

The taxiway was milled to approximately 1-1/4 in. below the existing white-painted pavement surface (Fig. 4). Because of some irregularities and depressions on the surface, not all of the white paint was removed (Fig. 5). Since this would prevent bonding of the overlay

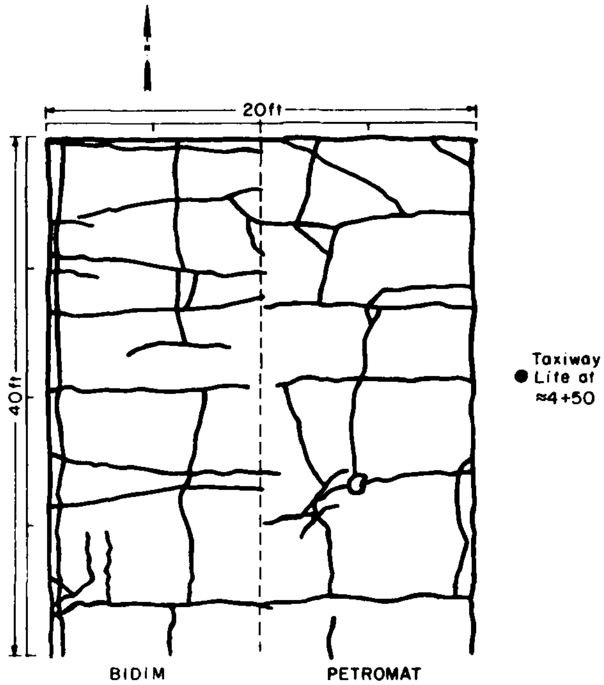


Figure 6. Preconstruction cracks in taxiway 3 (June 1978).

to the underlying surface, these "bird baths" were torched and the paint was peeled off with hand shovels. The depressions were then filled with a 5/8-in. asphalt mix and leveled with a shim layer.

The milled surface was cleaned with a tractor-mounted sweeper brush, and any cracks, ranging from 1/2 to 1 in. wide and deep, were cleaned, filled with a 3/8-in. asphalt mix, and compacted by a pneumatic roller. The cracks were filled by hand shovel, starting at the far southwest corner (station 2+50) and proceeding northward on the west side of the taxiway (Fig. 2). Upon reaching station 7+50, the direction was reversed and the cracks along the east side of taxiway 3 were filled. Crack filling and shimming provides a smooth surface, ensuring a good bond between the fabric and the milled surface.

During the crack filling operation, we saw that there were approximately four times as many cracks on the PETROMAT side (east) as on the BIDIM (west) side of taxiway 3. The cracks in the entire fabric area were remapped as they were significantly different than the premilling cracks which had been mapped four weeks before (Fig. 6-9).

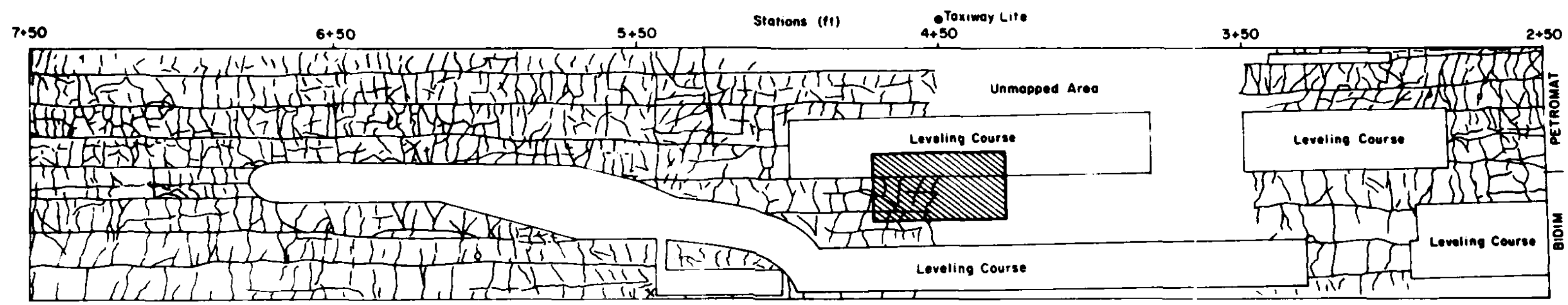
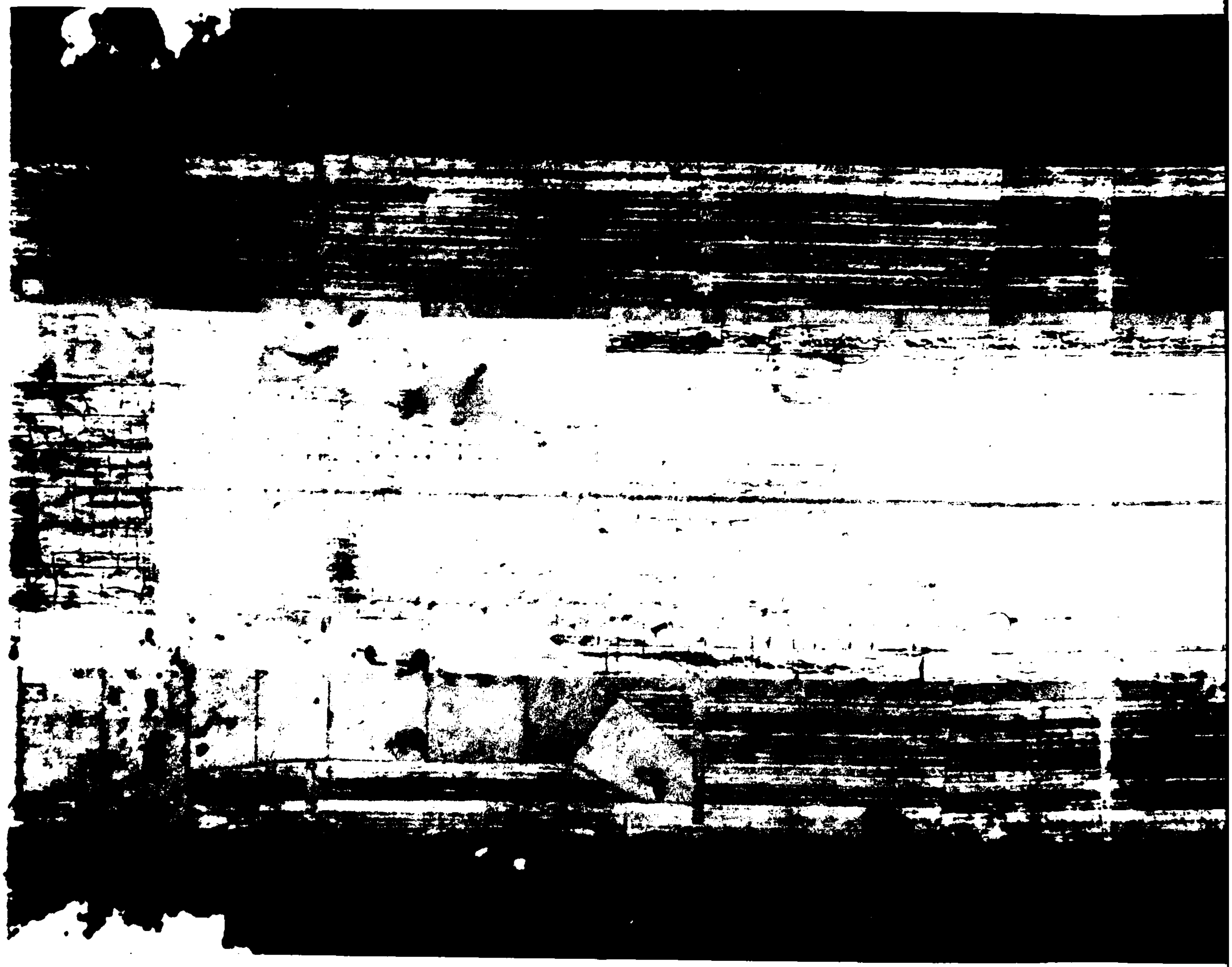
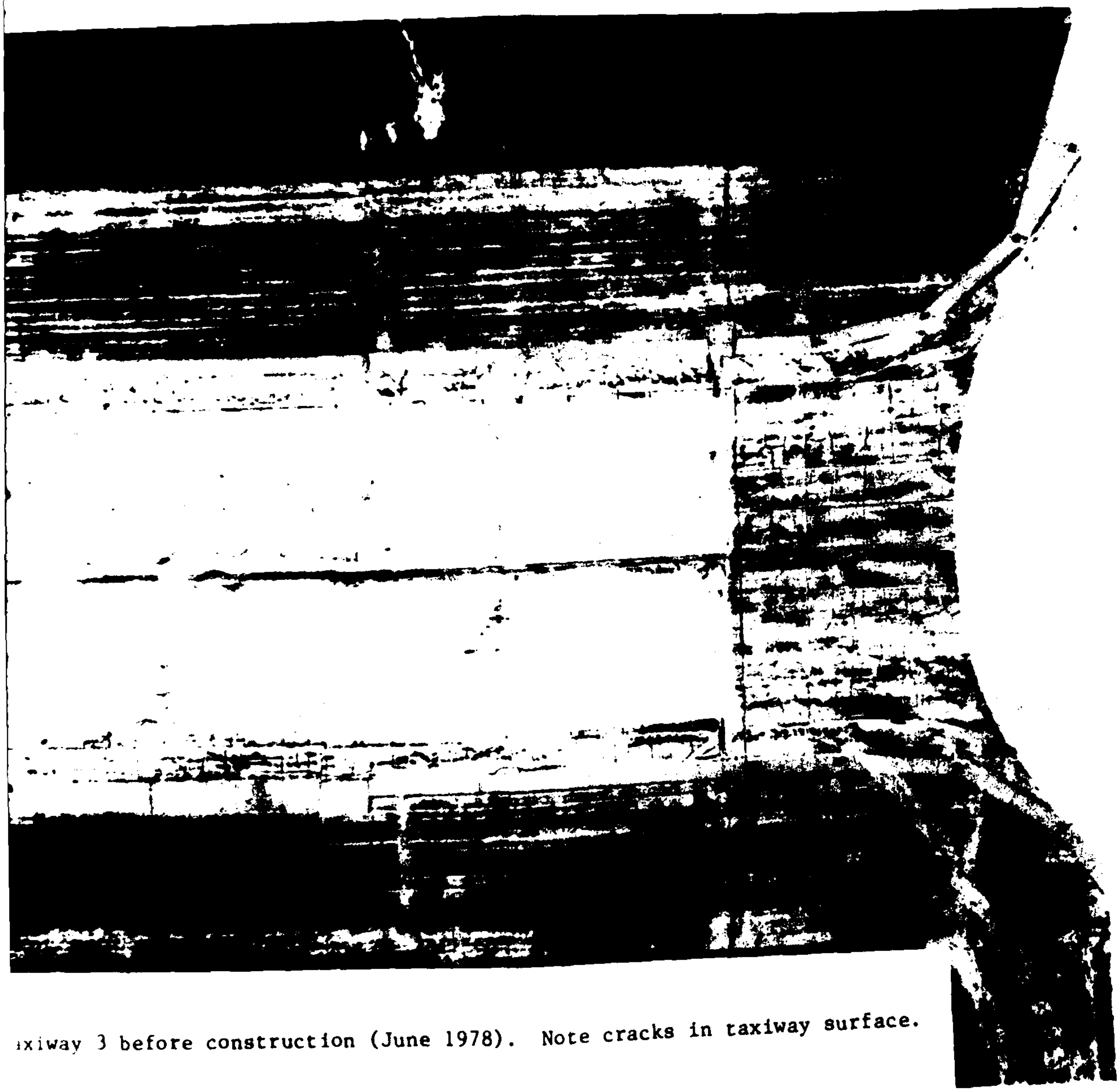


Figure 7. Map of cracks in taxiway 3 after milling (August 1978) (shaded area shown in Fig. 9).





ıxiway 3 before construction (June 1978). Note cracks in taxiway surface.

3

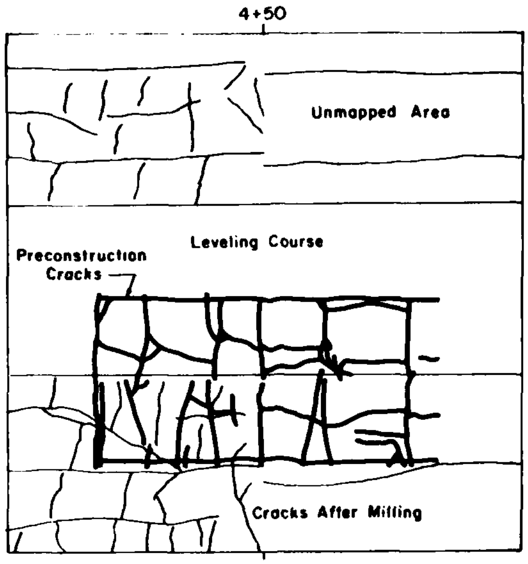


Figure 9. Preconstruction cracks in taxiway 3 (June 1978) overlaid on cracks left after milling (August 1978).

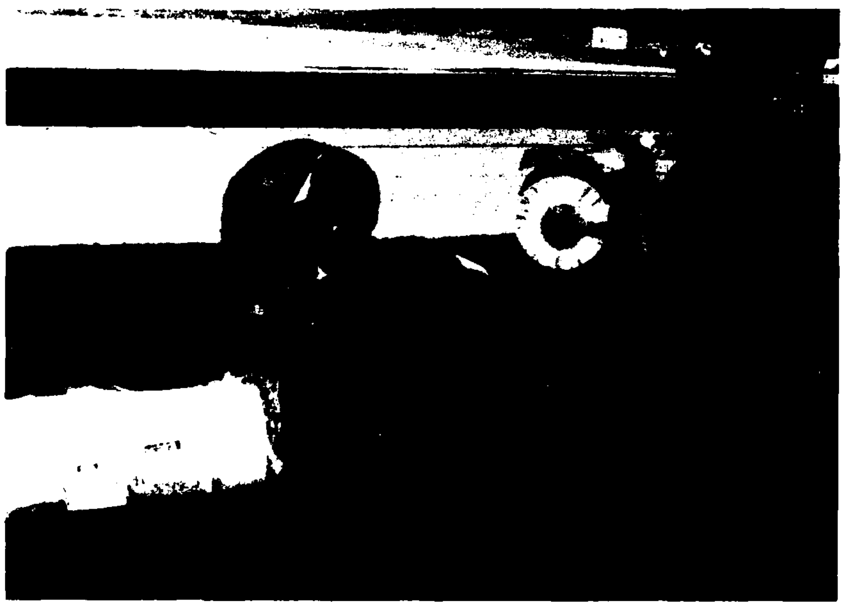


Figure 10. Attaching hand brake to roll of fabric.

Before the fabric was laid, the taxiway 3 test section was swept clear of all debris and laid out for correct dimensions and guidance. Equipment for installing the fabric consisted of a 1-in.-i.d. by 16-ft galvanized pipe that was inserted into the 3-in.-i.d. board core of the fabric rolls. Two roll-braking devices which attached to the ends of the pipe were furnished by a manufacturer's representative (Fig. 10).

Figure 11. Applying tack coat.

PETROMAT fabric installation

Each lane represents the width of the fabric (minus overlap). Numbers were arbitrarily assigned from east (lanes 1-3, PETROMAT side) to west (lanes 1-3, BIDIM side) across taxiway 3.

Fabric installation started on lane 1 at the southeast corner of taxiway 3 at station 2+50 (PETROMAT side), and proceeded directly north, approximately 8 ft away from the 3-1/2-ft-wide concrete light pad (Fig. 2). The temperature of the milled surface and of the tack coat, and the ambient temperatures were monitored with a Trendacotur model 402A thermocouple readout device supplied by one of the manufacturer's representatives. While the fabric was being laid, the surface temperature was $52° \pm 2°F$, the ambient air $46° \pm 5°F$, and the AC 2.5 tack coat application temperature was approximately 260°F (Appendix A).

The uncut AC 2.5 tack coat was applied to the milled surface from an internally heated pressure distributor which was towed by a tractor (Fig. 11). The tack coat application rate for the PETROMAT side ranged from 0.37 to 0.40 gal./yd^2, well within the specified rate range of 0.37 to 0.45 gal./yd^2 (Appendix B), and was applied to an area 6 to 8 in. wider than the fabric.

Two men followed 10 ft behind the distributor carrying the 176-lb roll of PETROMAT. The fabric was unrolled 20 to 25 ft at a time and was

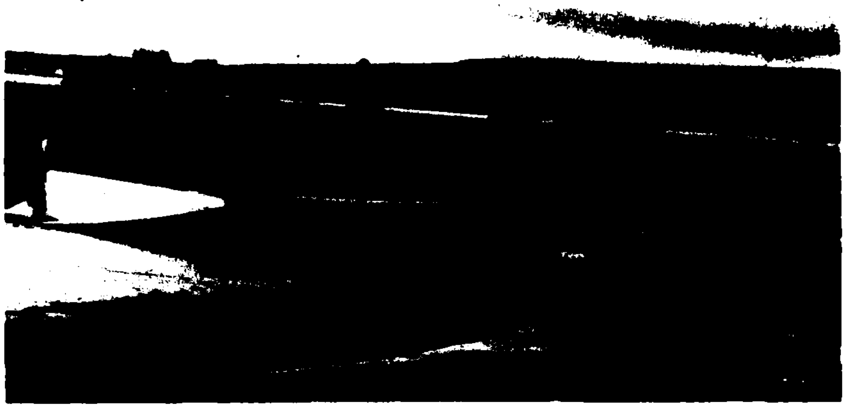


Figure 12. Placing fabric.

Figure 13. Sweeping out wrinkles in fabric.

stretched tight before it was lowered onto the tack coat (Fig. 12). Immediately following were three men with bristle push brooms who lightly brushed the fabric to remove all wrinkles (Fig. 13).

The fabric was laid down from south to north on lane 1 because of a bothersome 4 to 6 knot wind.

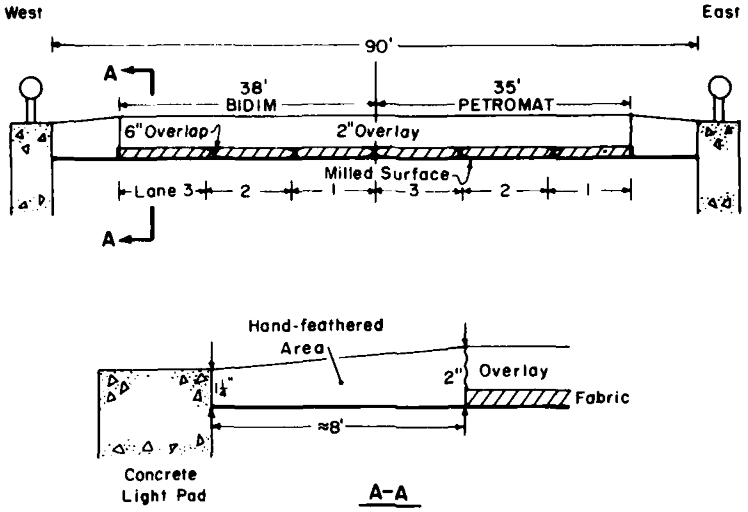


Figure 14. Cross section of taxiway 3 (not to scale).

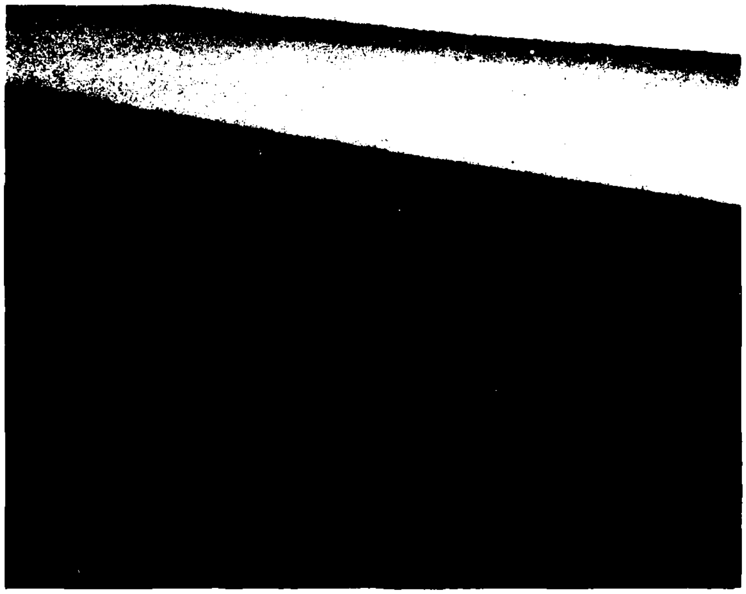


Figure 15. Wrinkle that was cut and overlapped.

The fabric wrinkled 30 ft from the start of lane 1 (station 2+80) (see Fig. 14 for location of lane 1) because of a misalignment with the tack coat. The fabric was cut with a pocketknife and then overlapped by 6 in. (Fig. 15). It wrinkled again at station 4+80 and was again cut and overlapped by the same amount. After the first roll ran out, the left-hand brake device was disassembled and the pipe was taken out and

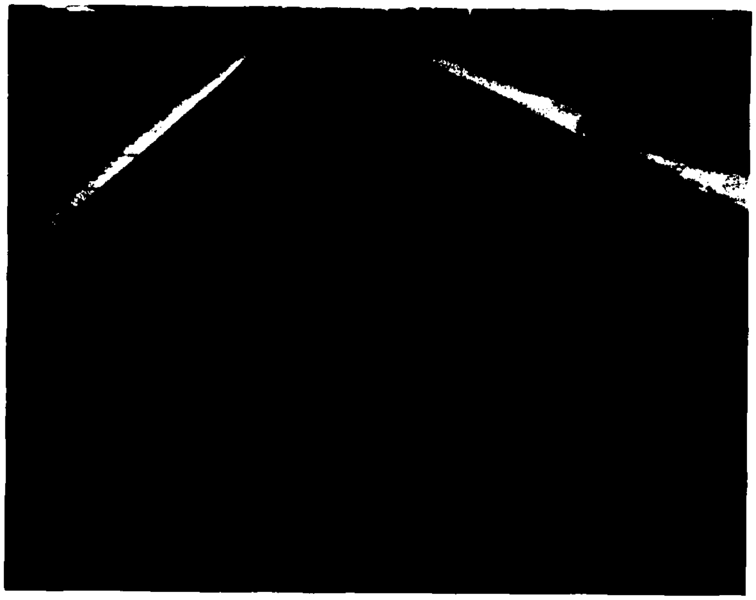


Figure 16. Tack coat bleeding through PETROMAT fabric.

inserted into the core of another full roll. The braking device was reinstalled and fabric application resumed with a 6-in. overlap. The pressure distributor applied the tack coat smoothly and uniformly throughout lane 1.

The second roll was laid in lane 1 (wrinkle free) from station 5+50 to 7+50, increasing the pace of the operation. The first lane (station 2+50 to 7+50) was completed in 1-1/2 hr. The tack coat bled through the fabric at stations 2+90, 3+00, and 3+05 in the center of the fabric (Fig. 16).

Lane 2 was laid in the same direction using the same method as lane 1. The distributor operated 12 to 15 ft ahead of the fabric which allowed the hot tack coat to cool before the fabric was laid. Just before the start of lane 3, the distributor ran out of AC 2.5 tack coat. Due to the cold weather, the asphalt remaining in the distributor pipelines solidified on its return to the asphalt plant, even though they were heated. Blow torches were used to heat the pipes between the tank and the bar. Three hours later the distributor was again operating properly.

Because of a sudden change in wind direction, the fabric was laid north to south on the third and final lane of the PETROMAT test area.

Both longitudinal and transverse fabric joints were overlapped by approximately 6 in. This lane was put down much faster, with the fabric following approximately 15 ft behind the distributor. The fabric was unrolled 30 ft at a time, stretched, laid and broomed free of wrinkles.

The tack coat bled lightly through the fabric in the center of the roll on lane 2 from station 2+30 to 3+00. The transverse joints were located at stations 3+44 and 4+50. On lane 3 the tack coat application rate was a uniform 0.35 gal./yd^2 and no bleeding resulted.

The distributor needed refilling for lane 3 and once again the pipes were heated after the AC 2.5 was loaded into the tank. While the distributor was being loaded the pneumatic roller passed over the fabric so that it would absorb the tack coat and improve the bond between the milled surface and the fabric. Two hours later the distributor was operating properly again and fabric installation resumed. The fabric was cut at station 5+30 and overlapped because of a 2-in. wrinkle. There was no evidence of bleeding or further wrinkling except for a small 4- x 4-ft section at station 3+70.

BIDIM fabric installation

The Monsanto BIDIM was laid in the same manner as the PETROMAT by starting at station 2+50 and proceeding northward with the two fabrics overlapping by 6 in. (Fig. 17). The BIDIM was laid much faster because

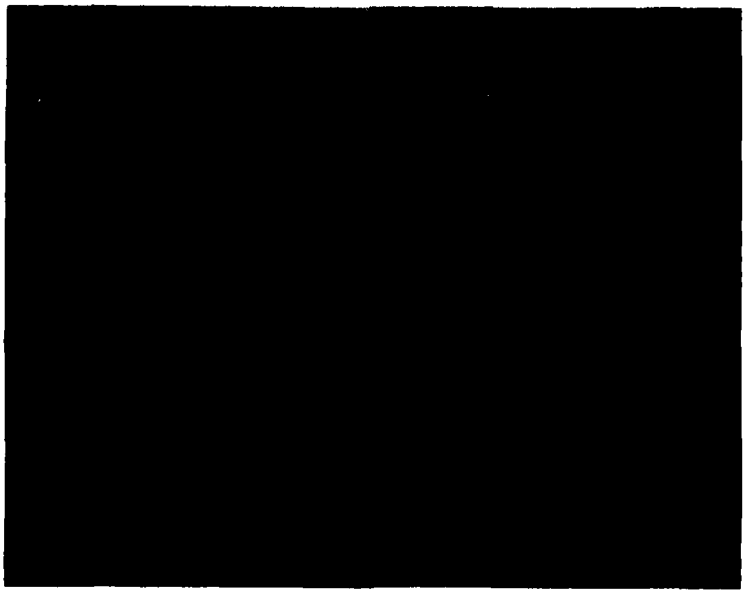


Figure 17. First BIDIM lane overlapping PETROMAT (note edge wrinkling).

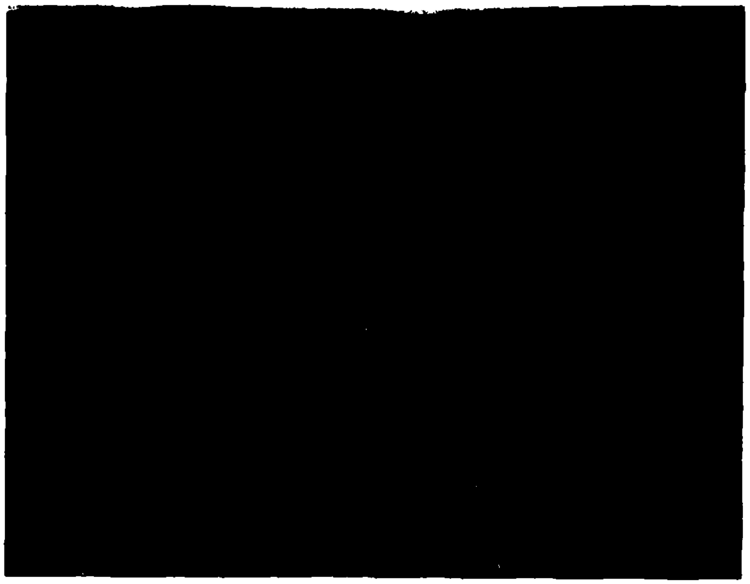


Figure 18. Joints between fabric lanes sealed prior to paving.

there was no wind and no bleeding or wrinkling. The pressure distributor sprayed the AC 2.5 approximately 15 ft in front of the fabric application crew at a uniform rate of 0.25 gal./yd^2. Lane 2 was also done smoothly; no bleeding or wrinkling were noticed.

Toward the end of the BIDIM installation the distributor was spraying 25-30 ft ahead of the fabric when it ran out of tack coat in lane 3. Because of previous trouble with the distributor when reloading, this section from 6+82 to 7+50 could not be tacked and no fabric was placed.

Before the 2-in. asphalt overlay was put down, the transverse joints in the fabric were sealed with an RC 250 cutback (Fig. 18). Instead of using the 40- and 39-ft test section widths in the original plan, 35 ft of PETROMAT and 38 ft of BIDIM were laid because of the fabric overlaps.

Asphalt concrete overlay

A 5/8-in. maximum size aggregate mix was used for the 2-in.-thick, single lift overlay. The mix was based on hot bin samples from the bituminous plant, and the Marshall test was used to analyze the asphalt. On-the-job inspection and testing were conducted by representatives from WES and the New York District.

Figure 19. Paving taxiway 3 on PETROMAT side.

A Barber Greene paving machine, which was equipped with an automatic sensing device to control the screen, paved a 12-ft lane. The steel cleats on the paving machine did not affect the fabric surface. The temperature of the asphalt as it was dumped from the truck into the paver was 270 ± 25°F. The PETROMAT side was paved first, proceeding south to north, in the same sequence by which the fabric was installed on the previous day (Fig. 19).

After each lane was paved, the edges were cut by a 2-ft-diameter steel wheel with a 1-1/2-in. blade attached (Fig. 20). The asphalt was then removed with hand shovels (Fig. 21). The edges and longitudinal joints were sealed with a hand-held spray applicator from the pressure distributor using an RC 250 cutback.

The thickness of the overlay was a nominal 2 in. wherever the fabric was placed. For the 8 ft of uncovered pavement from the edge of the fabric to the concrete light pad, the asphalt was hand placed and feathered to an overlay thickness of 1-1/4 in., equal to the depth of the milling operation (Fig. 14 and 22). It took 2 hr to place the first lane which covered a 20-ft-wide strip (12 ft for 2-in. overlay; 8 ft hand-feathered down to 1-1/4 in.).

The asphalt delivery truck tires stuck to the fabric where the tack coat had bled through the PETROMAT fabric. To prevent this, asphalt

Figure 20. Cutting wheel trimming construction joint.

Figure 21. Removing waste material.

concrete from the truck was hand broadcast in front of the tires as the truck backed up to the paver.

The only problem observed with the overlay developed between station 5+50 and 7+50 on the PETROMAT section where hairline cracking occurred. We thought the fabric was slipping under the 2-in. overlay.

Figure 22. Paving hand-feathered area adjacent to concrete light pad.

This could have been caused by excess tack coat, or by rolling the section before the asphalt had sufficiently cooled.

All of the fabric on taxiway 3 was overlaid in less than two days.

Taxiway 1 test section

A similar fabric test section was placed on the northeast warmup apron on the east end of taxiway 1 (Fig. 1 and 3).

The 4-oz/yd^2 PETROMAT was placed on the north side of the test area from station 2+00 to 7+00. The 8-oz/yd^2 BIDIM fabric was placed adjacent to the PETROMAT from 2+00 to 6+00 (Fig. 3).

The surface preparation, milling, tacking, fabric installation and paving procedures were identical to those carried out on taxiway 3.

SUMMARY

Both fabrics were installed under the strict supervision of the Monsanto and Phillips representatives. The actual fabric installation procedures used were as follows:

1. The white-painted pavement surface was milled to permit better bonding between the existing pavement, fabric and overlay.
2. Depressions in the taxiway were torched to remove white paint.

3. The above "birdbaths" were filled with a nominal 3/5-in. asphalt mix.
4. The proposed fabric laydown area was swept to remove all debris from the milled surface cracks.
5. These cracks were filled by hand with the same mix as used for the birdbaths.
6. An asphalt cement (AC 2.5) tack coat was applied and the fabric was placed on it.
7. Wrinkles in the fabric were removed by using hand push brooms or by cutting the fabric and overlapping ends.
8. The fabric was overlaid by a single 2-in. lift of asphalt concrete.

Overall, the installation was deemed proper and considered a job well done. All on-site personnel agreed that this would be a good test of whether or not reflection cracking could be prevented in such a harsh arctic environment. However, one problem was encountered with rolling the freshly placed asphalt before it cooled sufficiently. This resulted in cracking of the pavement surface at some locations on the taxiways.

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APPENDIX A. TEMPERATURE MEASUREMENTS OF TAXIWAY 3 OVERLAY.

Date: 9 August 1978
Time: 0805 hrs
Ambient temp.: 51°F
Milled surface temp.: 56°F
Location: Station 2+75 lane 1

Table A1. PETROMAT applications.*

Elapsed time (min)	Temperature under PETROMAT (°F)	Temperature on top of PETROMAT (°F)	Overlay surface temperature (°F)	Ambient (°F)
0	55	68	--	45
1.5	71	--	--	45
2	88	230	--	45
2.25	96	232	--	45
2.5	105	228	--	45
2.75	110	225	--	45
3	120	217	183	45
3.5	126	213	239	45
4	135	205	253	44
6	143	198	243	46
9	149	193	224	44
11	152	188	203	51
11.5	139	187	200	50
15.5	149	183	180	48
20 (roller)	148	176	163	46
25	146	169	150	48
30	140	158	139	46
35	138	153	132	48
40	136	148	124	43

* Instrument probes under and on top of the PETROMAT are approximately 10 ft west of the 3-1/2-ft-wide concrete light pad. The overlay surface probe was located 4 ft from the concrete pad.

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Date: 9 August 1978
Time: 0925 hrs
Ambient temp.: 39°F
Milled surface temp.: 47°F
Location: Station 7+20 lane 1

Table A2. PETROMAT applications.*

Elapsed time (min)	Temperature under PETROMAT (°F)	Temperature on top of PETROMAT (°F)	Overlay surface temperature (°F)	Ambient (°F)
0	144	214	--	--
1	166	200	253	43
2	167	196	254	44
5	165	188	207	52
6	165	185	204	43
9	165	187	189	46
12	163	178	187	50
18	159	171	161	47
20	158	169	158	49
173	98	103	93	58
332	78	79	74	47
411	--	70	--	41

* Instrument probes under and on top of PETROMAT are located approximately 8 ft west of the 3-1/2-ft-wide concrete light pad. The overlay surface probe was located at the same spot.

Date: 9 August 1978
Time: 1510 hrs
Ambient temp.: 42°F
Milled surface temp.: 50°F
Location: Station 3+50 lane 2

Table A3. PETROMAT application.*

Elapsed time (min)	Temperature under PETROMAT (°F)	Temperature on top of PETROMAT (°F)	Overlay surface temperature (°F)	Ambient (°F)
0	120	213	--	45
0.5	121	212	--	45
1	133	206	246	46
2	127	305	247	45
3	126	191	246	42
4	132	185	244	45
6	139	189	240	45
9	132	185	233	42
13	135	180	224	41
13.5	141	171	222	41
14	140	173	218	43
17	142	173	206	43
23	137	160	186	43
30	134	153	168	42
38	130	145	152	44
42	126	139	141	43
51	120	130	128	46
168**	87	88	71	39
215	83	83	64	38
286	80	80	63	38

* Instrument probes under and on top of the PETROMAT are located approximately 10 ft west of the 3-1/2-ft-wide concrete light pad. The overlay surface probe was located 4 ft from the concrete pad.

** Cloudy

Date: 10 August 1978
Time: 0820 hrs
Ambient temp.: 37°F
Milled surface temp.: 42°F
Location: Station 3+00 lane 1
(47-1/2 ft west of concrete pad)

Table A4. BIDIM application.*

Elapsed time (min)	Temperature under BIDIM (°F)	Temperature on top of BIDIM (°F)	Overlay surface temperature (°F)	Ambient (°F)
0	162	187	--	38
1	164	182	234	39
2	172	184	234	39
3	166	188	232	38
4	171	185	230	39
5	167	186	227	38
8	158	181	220	38
11	155	175	213	38
18	155	165	199	38
21	148	157	191	39
26	143	150	181	38
36	134	135	164	39
51	119	120	139	39
60	115	117	132	39

* Instrument probes under and on top of BIDIM are approximately 4 ft west of the taxiway center. The overlay surface probe was located approximately 4-1/2 ft west of the taxiway center.

Date: 10 August 1978
Time: 0850 hours
Ambient temp.: 46°F
Milled surface temp.: 52°F
Location: Station 3+00 lane 1

Table A5. BIDIM applications.*

Elapsed time (min)	Temperature under BIDIM (°F)	Temperature on top of BIDIM (°F)	Overlay surface temperature (°F)	Ambient (°F)
0	124	206	--	46
2	126	209	268	49
3	126	213	268	49
4	134	210	263	48
5	137	207	256	47
7	142	200	242	46
8	146	196	239**	46
11	153	187	214	45
13	154	176	193	46
17	151	170	176	45
22	144	162	151**	48
23	143	160	156**	59+
27	140	154	145	47
33	133	145	133	53
40	127	137	123	49
46	122	131	116	51
52	113	125	111	51
147	83	84	--	52

* Instrument probes under and on top of BIDIM are approximately 4 ft west of the taxiway center. The overlay surface probe was located approximately 4-1/2 ft from the taxiway center.

+ Instrument on pavement.

** Probe was moved to a new location.

APPENDIX B. JOB SPECIFICATIONS

Reflection cracking/fabric study (taxiway overlay), Thule AB, Greenland

Scope of work. Work involves placement of four sections of fabric in conjunction with the overlay of portions of the Thule taxiway during the summer of 1978. One study area is located on taxiway 3 and the other on the easterly portion of taxiway 1. The sections consist of the following fabrics: Monsanto BIDIM at 6 and 8 oz/yd^2 and Phillips Fibers PETROMAT at 4 and 6 oz/yd^2. The objective of the study is to assess the ability of these various fabrics to minimize reflection cracking in a severe cold environment. The fabric is to be furnished by the government.

Binder coat. Binder (tack) coat will be uncut AC 2.5 asphalt applied to the existing pavement at the following rates:

Section		Rate
PETROMAT	4 oz/yd^2	0.25 to 0.30 gal./yd^2
	6 oz/yd^2	0.37 to 0.45 gal./yd^2
BIDIM	4 oz/yd^2	0.25 to 0.35 gal./yd^2
	6 oz/yd^2	0.40 to 0.45 gal./yd^2

A manufacturer's representative from both Monsanto and Phillips Fibers will be present at Thule during fabric placement and will provide guidance on exact rate of binder coat application. Binder application must be smooth and temperature should be adjusted for most uniform application rate. Binder should be applied before fabric placement, but restricted to the immediate area of fabric placement.

Laying fabric. The fabric shall be laid to the dimensions shown on the attached drawings (not provided in this report). The overall dimensions of each section are:

Section		Dimensions
PETROMAT	4 oz/yd^2	51 x 600 ft
	6 oz/yd^2	39 x 500 ft
BIDIM	6 oz/yd^2	40 x 500 ft
	8 oz/yd^2	52 x 400 ft

There shall be at least a 6-in. overlap between rolls. The fabric will be furnished on rolls; the width of the BIDIM rolls is 166 in. and the PETROMAT rolls are 150 in. wide. Each roll will not exceed a weight of 175 lbs and thus can be handled by two men. A roll braking device will be supplied to facilitate the laydown procedure. Contractor shall furnish a 1-in. diameter pipe 14 ft, 6 in. long to which the brake is attached. Pavement must be clear of all sharp or angular protrusions. A typical manual laydown sequence is:

1. Attach support bar and brake devices to fabric roll, and adjust each brake to provide uniform drag (uneven drag may induce wrinkling).
2. With the free end of fabric held at the starting point, walk the roll in the direction of laydown, unrolling the fabric against the preset drag.
3. Unroll 20 to 50 ft (length will vary with crew experience, wind conditions, etc.), stretching the fabric taut and wrinkle-free. Lower into binder. Broom from center of roll outward in direction of laydown to establish uniform contact with binder. Moderate curves can be negotiated by adjusting drag on the outside brake higher than that on the inside brake. In no case should wrinkles large enough to cause laps or folds be permitted. Should this occur, slit, lay flat and patch over the cut area.

Joints in fabric. Transverse and longitudinal joints are made by overlapping the fabric by 6 in. Add additional binder to the joint as required; however, care must be taken not to apply excessive amounts as this may cause flushing. Should this occur, blot the asphalt-rich area with sand. It is suggested that transverse joints be "shingled" to minimize pickup by paving equipment. Should rain prior to overlay cause a blistered appearance and some bond loss, this can be corrected by pneumatic rolling until adhesion is restored.

Installation of overlay. Paving operations can follow fabric placement as soon as the membrane has cured. No cure time is needed for the asphalt cement binder, although the air temperature should be sufficient to allow adequate "tack" to hold the fabric in place. No tack coat is required on the binder. Fabric can withstand temperatures of 275 to 300°F without significant shrinkage or damage.

END

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